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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/751,207	01/02/2004	Huajie Chen	FIS920030350US1	5359

7590 11/23/2005
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EXAMINER	
NOVACEK, CHRISTY L	
ART UNIT	PAPER NUMBER
2822	

DATE MAILED: 11/23/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 10/751,207	Applicant(s) CHEN ET AL.	
	Examiner Christy L. Novacek	Art Unit 2822	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 09 September 2005.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-19 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-19 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 09 September 2005 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

This office action is in response to the amendment filed September 9, 2005.

Specification

The disclosure is objected to because of the following informalities: In the first line of the specification, the patent number of the application should be inserted.

Appropriate correction is required.

Drawings

The replacement drawings were received on September 9, 2005. These drawings are approved. The objections to the drawings are withdrawn.

Claim Rejections - 35 USC § 112

The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claims 1-19 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. As amended, independent claims 1, 10 and 19 recite the limitation of performing a chemical oxide removal process on a surface so as to remove oxygen from the surface and leaving a remaining amount of oxygen at the surface “wherein the remaining amount of oxygen

Art Unit: 2822

comprises less than 5×10^{12} atoms/cm²” (emphasis added). This is the opposite of what

Applicant recites throughout the specification. Applicant’s attention is directed to:

Page 5, paragraph 0020 of the specification, “When a small amount of oxygen remains ($> 5 \times 10^{12}$ /cm²), the surface stays smooth.”

Page 6, paragraph 0021 of the specification, “However, the small amount of oxygen ($> 5 \times 10^{12}$ /cm²) remains in the region to prevent surface roughening.”

Page 6, paragraph 0022 of the specification, “This HF etch process removes most of the oxide at the surface, however, a small amount of oxygen remains at the surface, typically with a dose of $1 \times 10^{13} - 1 \times 10^{15}$ /cm² oxygen... The higher the Ge content, the more remaining oxygen. An oxygen dose of $5 \times 10^{13} - 2 \times 10^{14}$ /cm² is typically observed on SiGe surface with 15-25% Ge content, while higher oxygen doses are possible with a non-optimized HF etch process.”

Page 7, paragraph 0025 of the specification, “The inventors found the surface stays smooth when there is a small amount of oxygen (e.g., sub-monolayer) remaining at the surface ($> 5 \times 10^{12}$ /cm²). For example, a $10\mu\text{m} \times 10\mu\text{m}$ AFM image taken before and after the hydrogen bake shows less than 1 Å RMS roughness change for the samples with at least 5×10^{12} /cm² oxygen remaining”.

Applicant’s specification states that the concentration of oxygen at the surface after the ex-situ oxide removal process must be **greater** than 5×10^{12} /cm² to avoid surface roughness and does **not** ever state that the concentration can be **less** than 5×10^{12} /cm². Therefore, the limitations in claims 1-19 that the remaining amount of oxygen is **less** than 5×10^{12} atoms/cm² are not supported by the original specification and/or original claims of the application.

Claim Rejections - 35 USC § 103

The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

Claims 1-4, 6-14 and 16-19 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted prior art in view of Comita et al. (US 6,774,040).

Regarding claim 1, the admitted prior art discloses performing an ex-situ chemical oxide removal process on a silicon germanium (SiGe) surface so as to remove oxygen from the SiGe

Art Unit: 2822

surface, thereby leaving a remaining amount of oxygen at the SiGe surface, heating the SiGe surface in a hydrogen bake to remove the remaining amount of oxygen from the SiGe surface, and epitaxially growing an epitaxial silicon-containing layer on the SiGe surface (pg. 4, para. 0017 – pg. 5, para. 0020). The admitted prior art discloses that this oxygen removal process results in a rough SiGe surface. The admitted prior art does not disclose that the hydrogen bake step includes heating the SiGe surface in a chlorine-containing environment. Like the admitted prior art, Comita discloses a method of preparing a semiconductor surface, which may include SiGe, for subsequent silicon epitaxial deposition, wherein the method of preparing the semiconductor surface involves subjecting the surface to a hydrogen bake (col. 1, ln. 35-63; col. 7, ln. 8-25). Comita teaches that by adding HCl and a silane-type gas to the hydrogen bake step, the semiconductor surface can be prepared such that it has the exceptional smoothness that is advantageous in the art (col. 1, ln. 35-63). Comita teaches that the ratio of the gases within the chlorine-containing environment can be adjusted so that no silicon is deposited onto the semiconductor surface (col. 11, ln. 41-67). At the time of the invention, it would have been obvious to one of ordinary skill in the art to add HCl and a silane-type gas to the hydrogen bake step of the admitted prior art because the admitted prior art recognizes that surface roughness is a problem and Comita teaches that by adding the HCl and silane-type gas to the hydrogen bake step, surface roughness can be avoided. The admitted prior art does not state the specific amount of oxygen that is left remaining after the ex-situ chemical oxide removal process. However the admitted prior art states, “A typical HF etch (the ex-situ chemical oxide removal process) will remove most of the native oxide, but still leaves a small amount of oxide, but still leaves a small amount of oxygen 30 at the SiGe surface” (paragraph 0021). Therefore, it appears that the

Art Unit: 2822

conventional HF etch disclosed by the admitted prior art inherently leaves an amount of oxygen at the semiconductor surface that is within the range recited by Applicant.

Regarding claims 2 and 12, Comita teaches that by using the H_2/HCl /silane-type gas heating method, the semiconductor surface can be formed such that it has a total RMS value of less than 0.1 nm (1.0 Angstrom).

Regarding claims 3 and 13, the admitted prior art and Comita disclose that the epitaxial silicon-containing layer can be silicon (Si).

Regarding claims 4 and 14, the admitted prior art discloses that the ex-situ chemical oxide removal involves a hydrofluoric acid etch.

Regarding claims 6, 9, 16 and 18, Comita discloses that the chlorine-containing hydrogen bake environment includes a mixture of a larger flow of hydrogen with smaller flows of HCl and dichlorosilane (DCS) (col. 13, ln. 7-25; col. 11, ln. 64 – col. 12, ln. 19).

Regarding claims 7, 8 and 17, Comita discloses that the ratio of HCl and DCS can be varied according to the degree of smoothness desired (col. 3, ln. 49-57; col. 11, ln. 23 – col. 12, ln. 29). At the time of the invention, it would have been obvious to one of ordinary skill in the art to select a ratio of HCl and DCS that provides either a zero or positive etch rate because Comita teaches that the ratio of HCl and DCS can be varied according to the degree of smoothness desired.

Regarding claim 10, the admitted prior art discloses performing an ex-situ chemical oxide removal process on a silicon surface so as to remove oxygen from the silicon surface, thereby leaving a remaining amount of oxygen at the silicon surface, heating the silicon surface in a hydrogen bake to remove the remaining amount of oxygen from the silicon surface, and

Art Unit: 2822

epitaxially growing an epitaxial silicon-containing layer on the silicon surface (pg. 4, para. 0017 – pg. 5, para. 0020). The admitted prior art discloses that this oxygen removal process results in a rough silicon surface. The admitted prior art does not disclose that the hydrogen bake step includes heating the silicon surface in a chlorine-containing environment. Like the admitted prior art, Comita discloses a method of preparing a silicon surface for subsequent silicon epitaxial deposition, wherein the method of preparing the silicon surface involves subjecting the surface to a hydrogen bake (col. 1, ln. 35-63; col. 7, ln. 8-25). Comita teaches that by adding HCl and a silane-type gas to the hydrogen bake step, the silicon surface can be prepared such that it has the exceptional smoothness that is advantageous in the art (col. 1, ln. 35-63). Comita teaches that the ratio of the gases within the chlorine-containing environment can be adjusted so that no silicon is deposited onto the semiconductor surface (col. 11, ln. 41-67). At the time of the invention, it would have been obvious to one of ordinary skill in the art to add HCl and a silane-type gas to the hydrogen bake step of the admitted prior art because the admitted prior art recognizes that surface roughness is a problem and Comita teaches that by adding the HCl and silane-type gas to the hydrogen bake step, surface roughness can be avoided. The admitted prior art does not state the specific amount of oxygen that is left remaining after the ex-situ chemical oxide removal process. However the admitted prior art states, “A typical HF etch (the ex-situ chemical oxide removal process) will remove most of the native oxide, but still leaves a small amount of oxide, but still leaves a small amount of oxygen 30 at the SiGe surface” (paragraph 0021). Therefore, it appears that the conventional HF etch disclosed by the admitted prior art inherently leaves an amount of oxygen at the semiconductor surface that is within the range recited by Applicant.

Regarding claim 11, the admitted prior art does not disclose any particular type of semiconductor substrate or integrated circuit device. Comita teaches that his surface smoothing method is applicable to a SOI substrate. At the time of the invention, it would have been obvious to one of ordinary skill in the art to apply the methods taught by the admitted prior art and Comita to any semiconductor substrate or surface on which surface roughness is desired to be smoothed because, as is stated by the admitted prior art, surface roughness is a well-known problem and because strained silicon surfaces and patterned thin silicon-on-insulator substrates are well-known in the art.

Regarding claim 19, the admitted prior art discloses performing an ex-situ chemical oxide removal process on a silicon surface so as to remove oxygen from the silicon surface, thereby leaving a remaining amount of oxygen at the silicon surface, heating the silicon surface in a hydrogen bake to remove the remaining amount of oxygen from the silicon surface, and epitaxially growing an epitaxial silicon-containing layer on the silicon surface (pg. 4, para. 0017 – pg. 5, para. 0020). The admitted prior art discloses that this oxygen removal process results in a rough silicon surface. The admitted prior art does not disclose that the hydrogen bake step includes heating the silicon surface in a chlorine-containing environment. Like the admitted prior art, Comita discloses a method of preparing a silicon surface for subsequent silicon epitaxial deposition, wherein the method of preparing the silicon surface involves subjecting the surface to a hydrogen bake (col. 1, ln. 35-63; col. 7, ln. 8-25). Comita teaches that by adding HCl and a silane-type gas to the hydrogen bake step, the silicon surface can be prepared such that it has the exceptional smoothness that is advantageous in the art (col. 1, ln. 35-63). At the time of the invention, it would have been obvious to one of ordinary skill in the art to add HCl and a

Art Unit: 2822

silane-type gas to the hydrogen bake step of the admitted prior art because the admitted prior art recognizes that surface roughness is a problem and Comita teaches that by adding the HCl and silane-type gas to the hydrogen bake step, surface roughness can be avoided. The admitted prior art does not disclose any particular type of semiconductor substrate or integrated circuit device. Comita teaches that his surface smoothing method is applicable to a SOI substrate. Comita teaches that the ratio of the gases within the chlorine-containing environment can be adjusted so that no silicon is deposited onto the semiconductor surface (col. 11, ln. 41-67). At the time of the invention, it would have been obvious to one of ordinary skill in the art to apply the methods taught by the admitted prior art and Comita to any semiconductor substrate or surface on which surface roughness is desired to be smoothed because, as is stated by the admitted prior art, surface roughness is a well-known problem and because strained silicon surfaces and patterned thin silicon-on-insulator substrates are well-known in the art. The admitted prior art does not state the specific amount of oxygen that is left remaining after the ex-situ chemical oxide removal process. However the admitted prior art states, "A typical HF etch (the ex-situ chemical oxide removal process) will remove most of the native oxide, but still leaves a small amount of oxide, but still leaves a small amount of oxygen 30 at the SiGe surface" (paragraph 0021). Therefore, it appears that the conventional HF etch disclosed by the admitted prior art inherently leaves an amount of oxygen at the semiconductor surface that is within the range recited by Applicant.

Claims 5 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted prior art in view of Comita et al. (US 6,774,040), as applied to claims 1 and 10 above, and further in view of Paton et al. (US 6,811,448).

Regarding claims 5 and 15, the admitted prior art does not disclose any particular formulation for the hydrofluoric acid etch. Like the admitted prior art, Paton disclose using a HF etch to remove native oxide from the surface of a semiconductor substrate. Paton teaches that a H₂O:HF solution of anywhere from 50:1 to 1000:1 (col. 4, ln. 22-38). At the time of the invention, it would have been obvious to one of ordinary skill in the art to use a H₂O:HF solution of 50:1 to 1000:1 because the admitted prior art does not disclose any particular formulation for the HF etch and Paton discloses that a H₂O:HF ratio of 50:1 to 1000:1 can successfully accomplish the removal of native oxide from a semiconductor substrate.

Response to Arguments

Applicant's arguments filed September 9, 2005 have been fully considered but they are not persuasive.

Regarding the rejection of claims 1, 10 and 19 as being unpatentable over the admitted prior art in view of Comita, Applicant argues that the admitted prior art allegedly fails to disclose performing the HF etch (ex-situ chemical oxide removal process) such that the remaining amount of oxygen at the semiconductor surface is the same as that of Applicant's. First, Applicant's argument that the admitted prior art fails to teach etching the semiconductor surface such that it has **less** than 5×10^{12} atoms/cm² is inappropriate, in so far as Applicant's original specification and claims state that the semiconductor surface must have **more** than 5×10^{12} atoms/cm² residual oxygen. Furthermore, Applicant's paragraph 0022 states, "An oxygen dose of $5 \times 10^{13} - 2 \times 10^{14}$ /cm² is typically observed on SiGe surface with 15-25% Ge content, while higher oxygen doses are possible with a non-optimized HF etch process." Thereby, it appears

Art Unit: 2822

that Applicant admits that the typical (“non-optimized”) HF etch can be used to achieve a semiconductor surface having the amount of residual oxygen recited by Applicant.

Further regarding the rejection of claims 1, 10 and 19 as being unpatentable over the admitted prior art in view of Comita, Applicant argues that Comita allegedly fails to disclose processing the silicon surface in a chlorine-containing environment without depositing silicon onto the silicon surface. Comita recites,

“The first gas mixture **252** and the second gas mixture **254**, can be used to smooth a silicon surface and to **maintain** a thickness for the silicon, such as, for example, on the wafer **213**.” (emphasis added, col. 7, ln. 8-11).

“In one embodiment where, for example, more than 100 nm of silicon film 302 is to be removed, first a high HCl:H₂ molecular concentration ratio is used to provide a high removal rate to remove the bulk of the silicon film, and then the mixture ratio is changed “in process” to a low HCl:H₂ molecular concentration ratio to reduce the removal rate towards the end of the treatment process.” (col. 11, ln. 41-47).

Therefore, Comita teaches that the ratio of gases used in the chlorine-containing environment can be used not just to add silicon to the wafer surface but also to maintain the thickness of the wafer surface or to remove an amount of the wafer surface.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37

Art Unit: 2822


CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Christy L. Novacek whose telephone number is (571) 272-1839. The examiner can normally be reached on Monday-Thursday and alternate Fridays 7:30 - 5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Zandra Smith can be reached on (571) 272-2429. The fax phone number for the organization where this application or proceeding is assigned is (571) 273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

CLN
November 15, 2005

Supervisory

ZANDRA V. SMITH
PRIMARY EXAMINER
11/21/05